LOCAL DEFORMATION MONITORING USING REAL-TIME GPS KINEMATIC TECHNOLOGY: INITIAL STUDY

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UNB RTK SYSTEM

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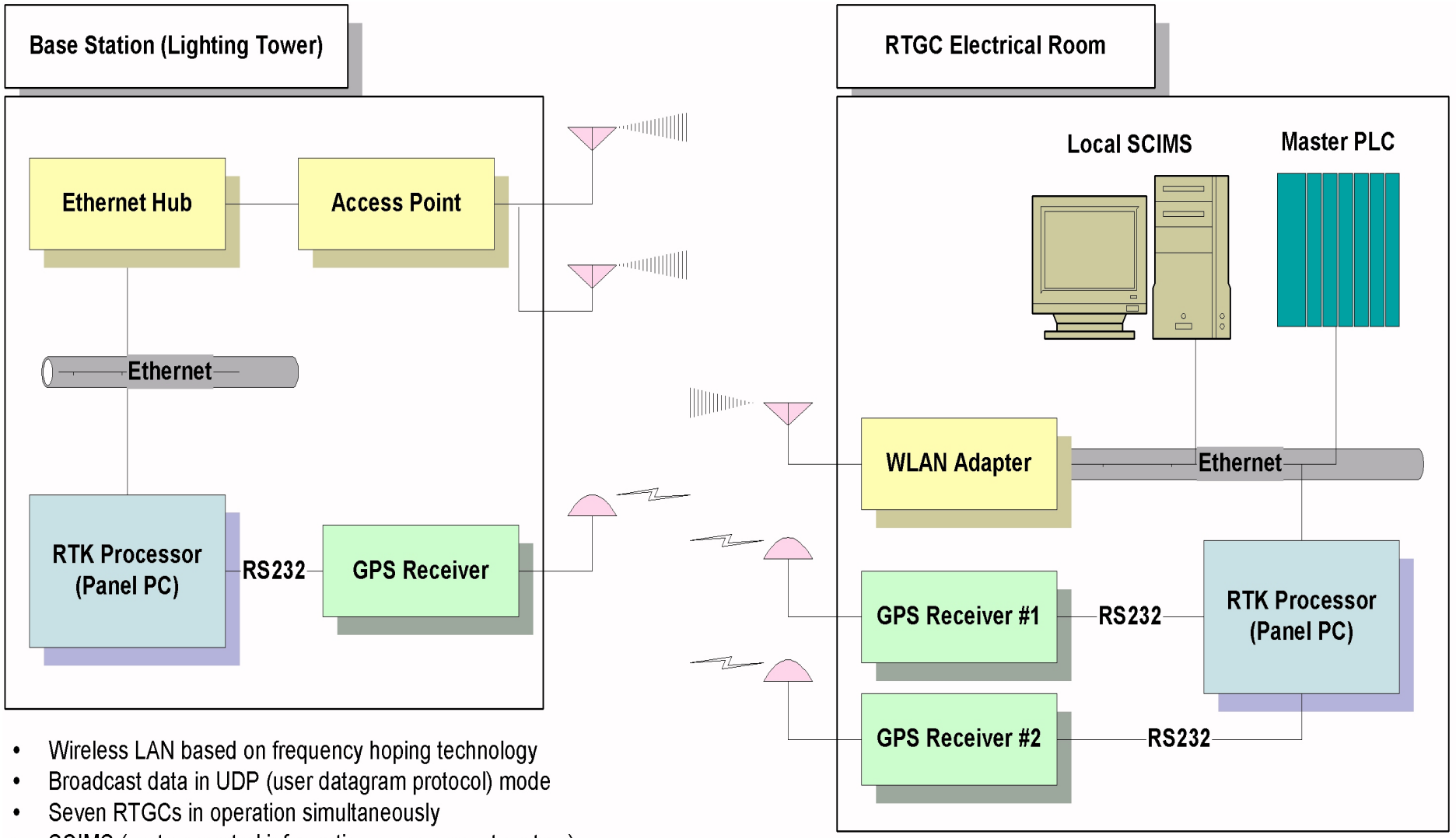


- Wireless LAN based on frequency hoping technology
- Broadcast data in UDP (user datagram protocol) mode
- Seven RTGCs in operation simultaneously
- SCIMS (system control information management system)

HIGHLAND VALLEY COPPER MINE

DESCRIPTION OF PROBLEM

- Current deformation monitoring system utilizes robotic total stations (RTS) retroreflecting prisms
- To reduce pointing errors and atmospheric refraction effects, distances to targets must be within a few hundred metres
- RTSs located in an unstable environment with a limited visibility

PROPOSED SOLUTION

- Combine robotic total stations with GPS to control the stability of the RTS

- Two requirements:
  - Accuracy of controlling the stability of the RTSs must be within a few millimetres at the 95% confidence level (particularly in height changes), and
  - RTS position corrections must be derived from GPS data in a fully automated mode.

RTS/GPS STATION

GPS BIASES AND ERRORS

- Residual tropospheric delay:
  - Tropospheric delay not accurately predicted by empirical models
  - Possibly the largest remaining error source in dual-frequency precision positioning
  - In the mine, primarily resulting from station height differences

- Multipath:
  - Specular reflection vs. diffraction and diffusion
  - In an open pit mine, diffraction and diffusion are more common

UNB APPROACH

- UNB3 Composite Tropospheric Delay Model
  - Zenith delay algorithms of Saastamoinen
  - Mapping functions of Niell
  - Look-up table of five atmospheric parameters

- Multipath Mitigation
  - An optimal inter-frequency carrier phase linear combination of the L1 and L2 observations
  - A smoothing process (e.g., sequential least-squares estimation)

INITIAL TEST

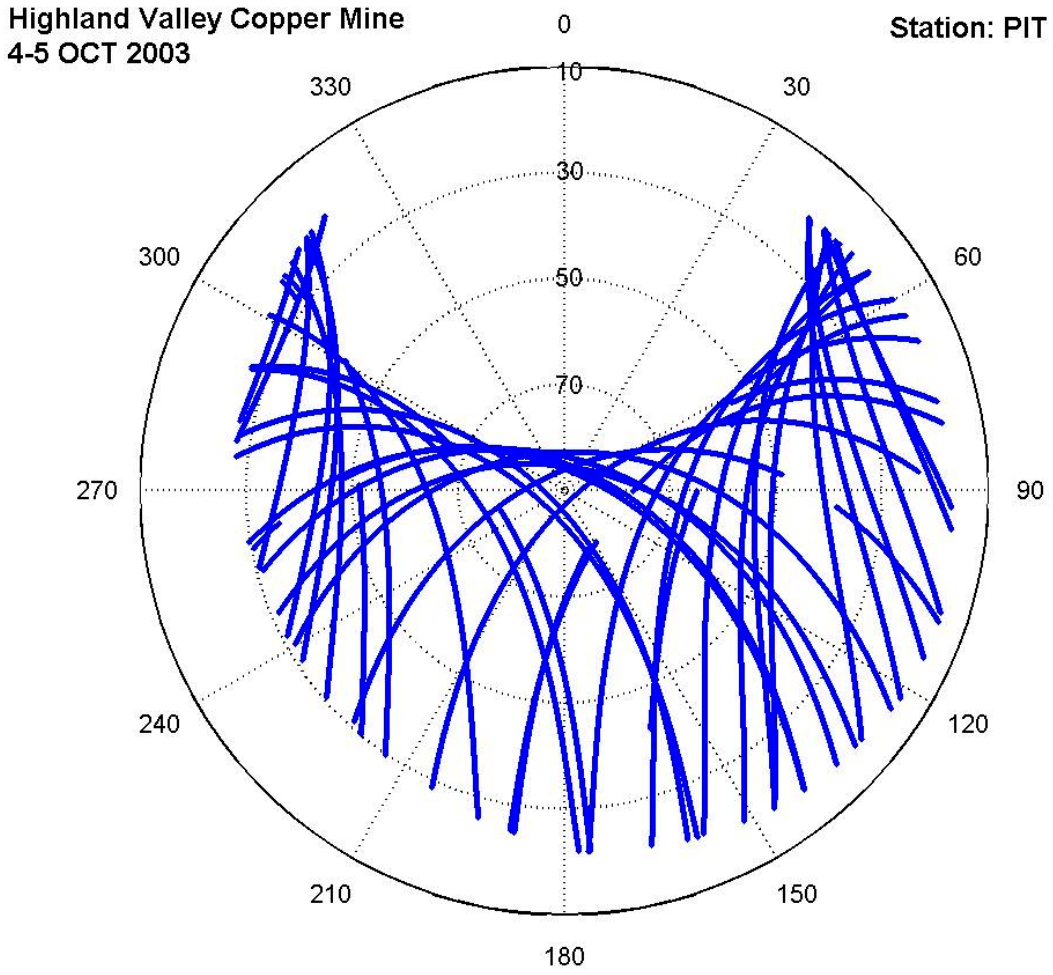
- Experiment early October 2002
- Four geodetic performance dual-frequency GPS receivers and antennas (NovAtel OEM4 receivers and GPS-600 pinwheel antennas)
- Reference station (MAST) setup outside the pit
- Three monitoring stations (RTS1, RTS2 and PIT) located inside the pit


RTS-2
Pit
N
RTS-1
0 120 240 360 480 600 metres
Network
MAST

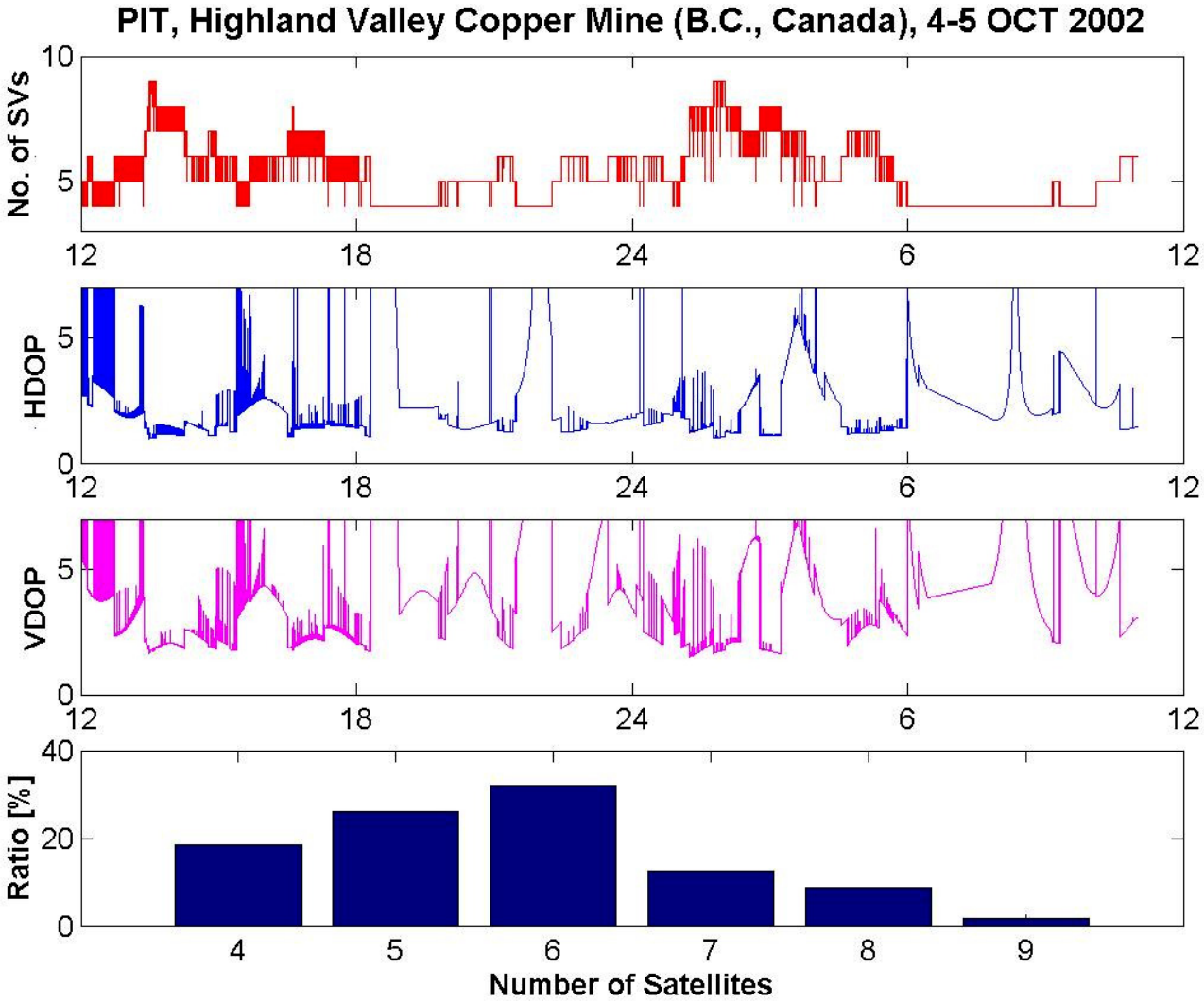
TEST CONDITIONS

Monitoring Stations	Slant distance (km)	Height difference (km)
RTS1-MAST	1.4	-0.5
RTS2-MAST	2.2	-0.4
PIT-MAST	1.8	-0.6

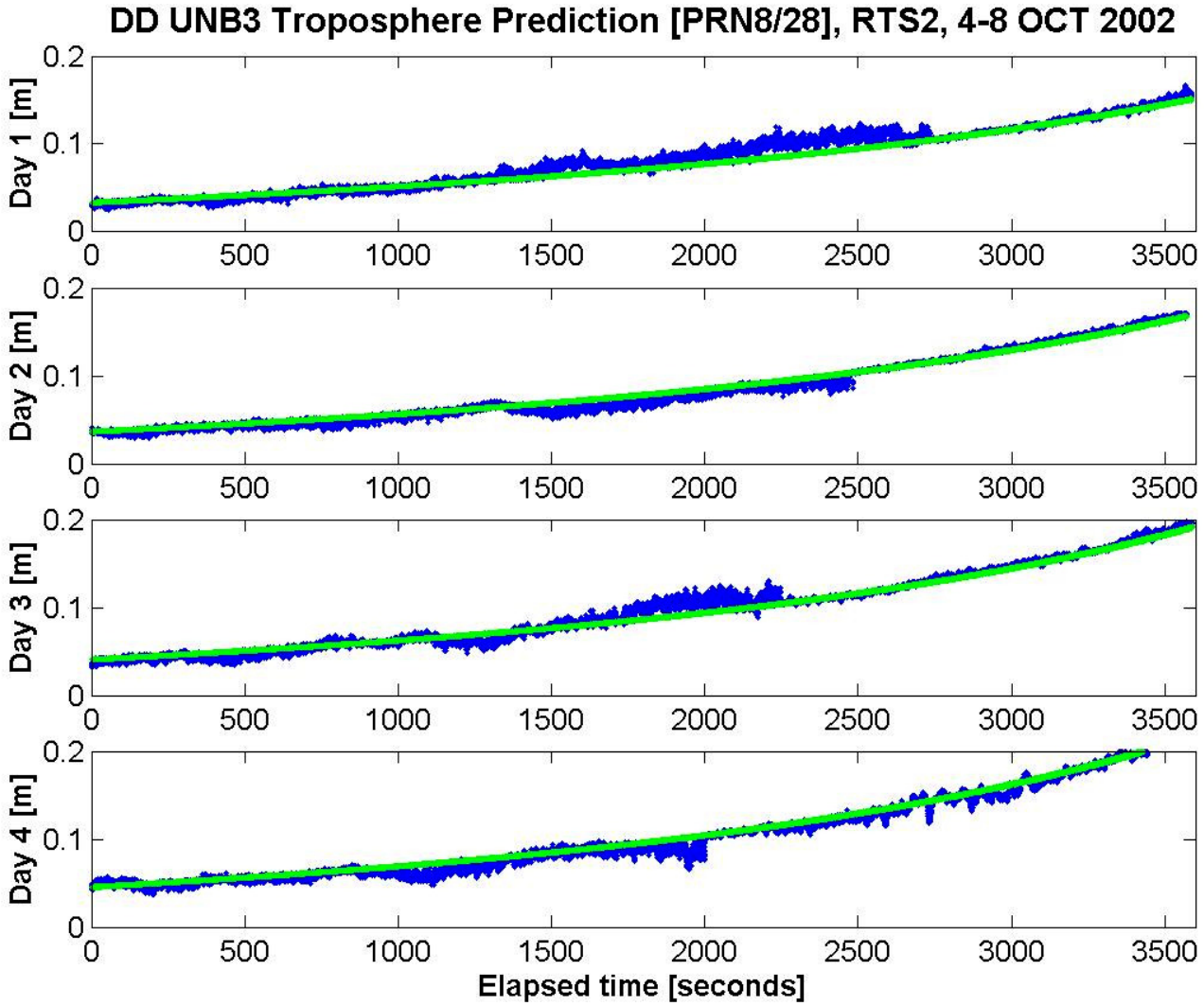
TEST CONDITIONS



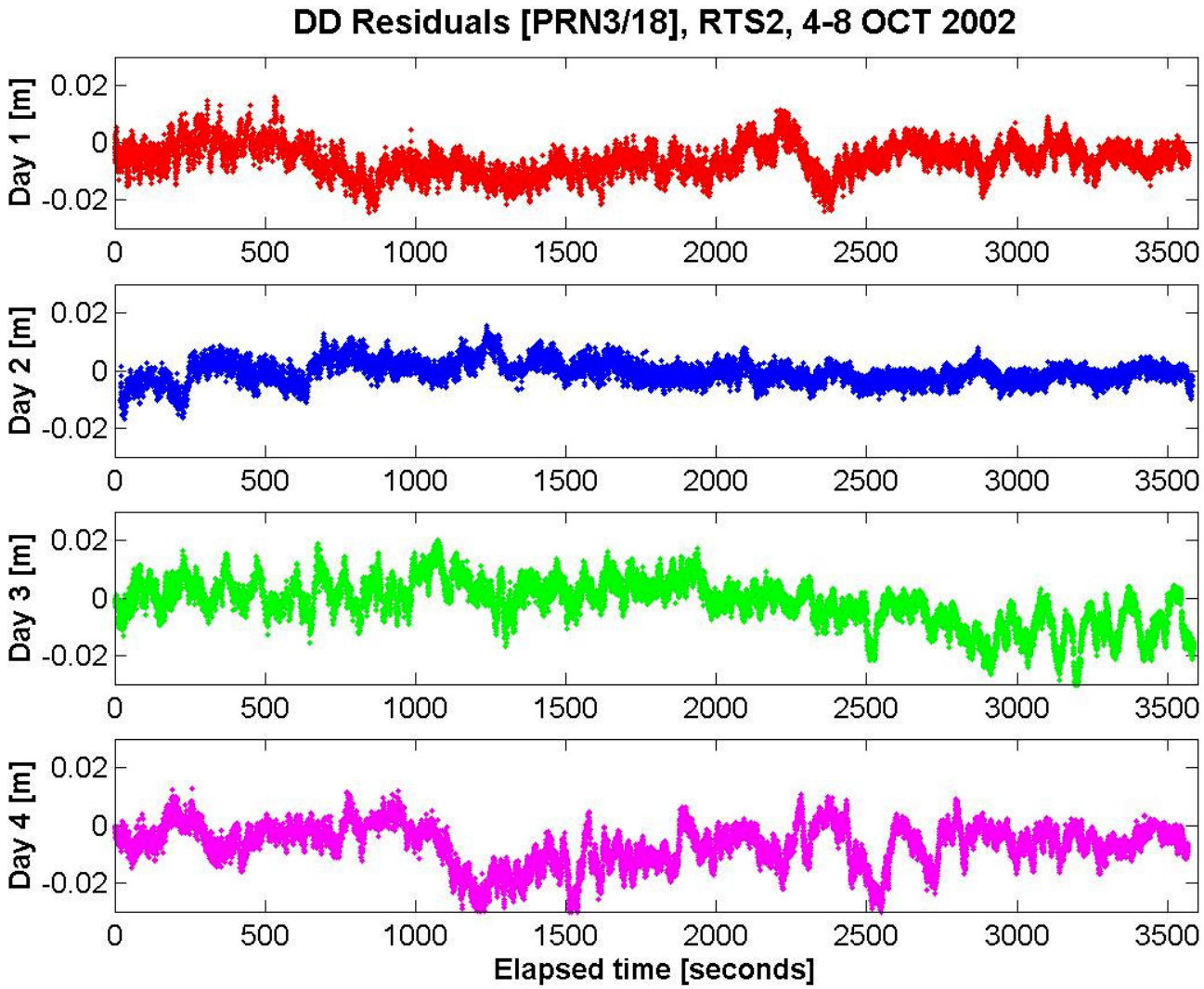
TEST CONDITIONS



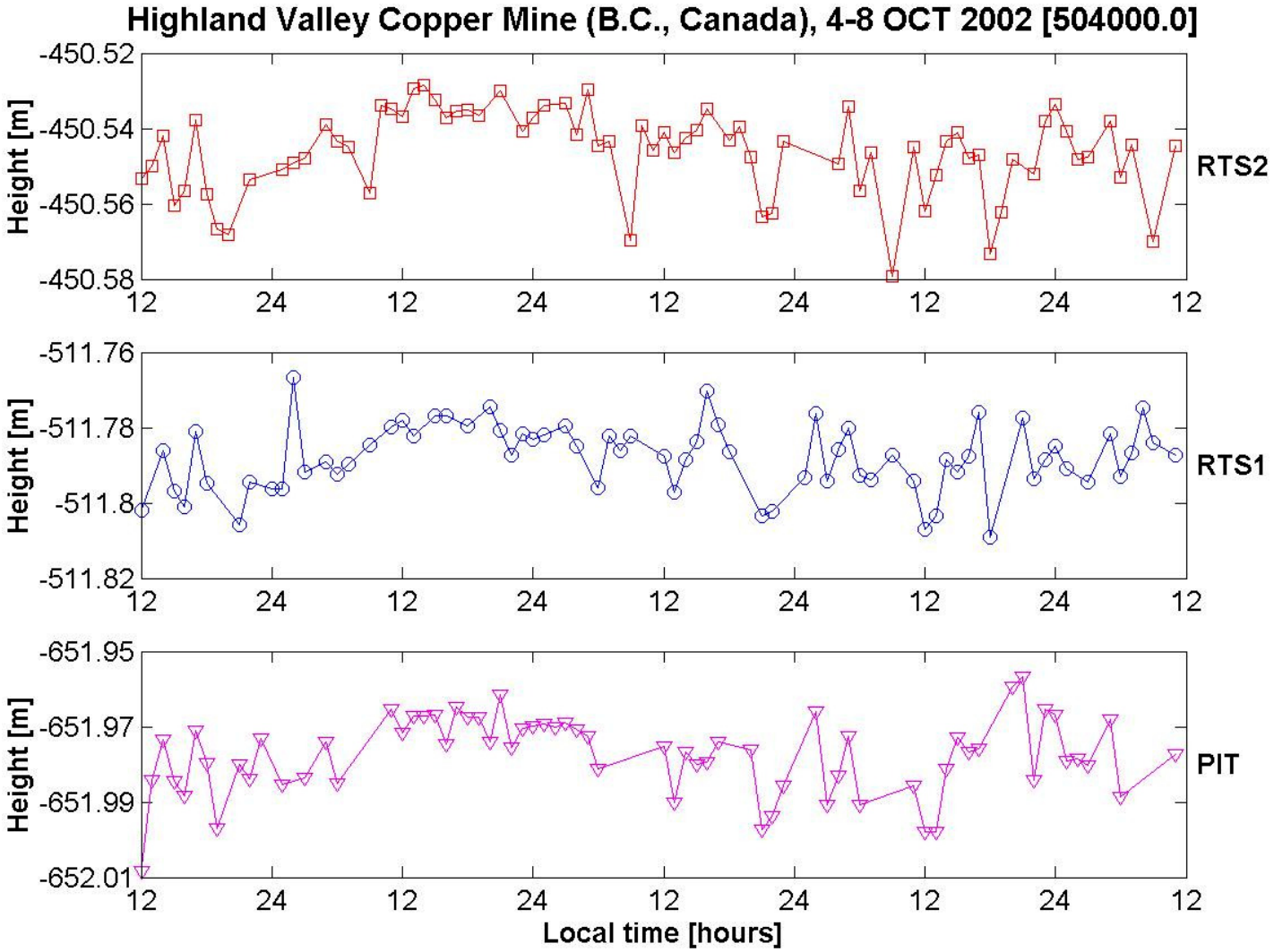
DD TROPOSPHERIC DELAY "OBSERVATIONS"



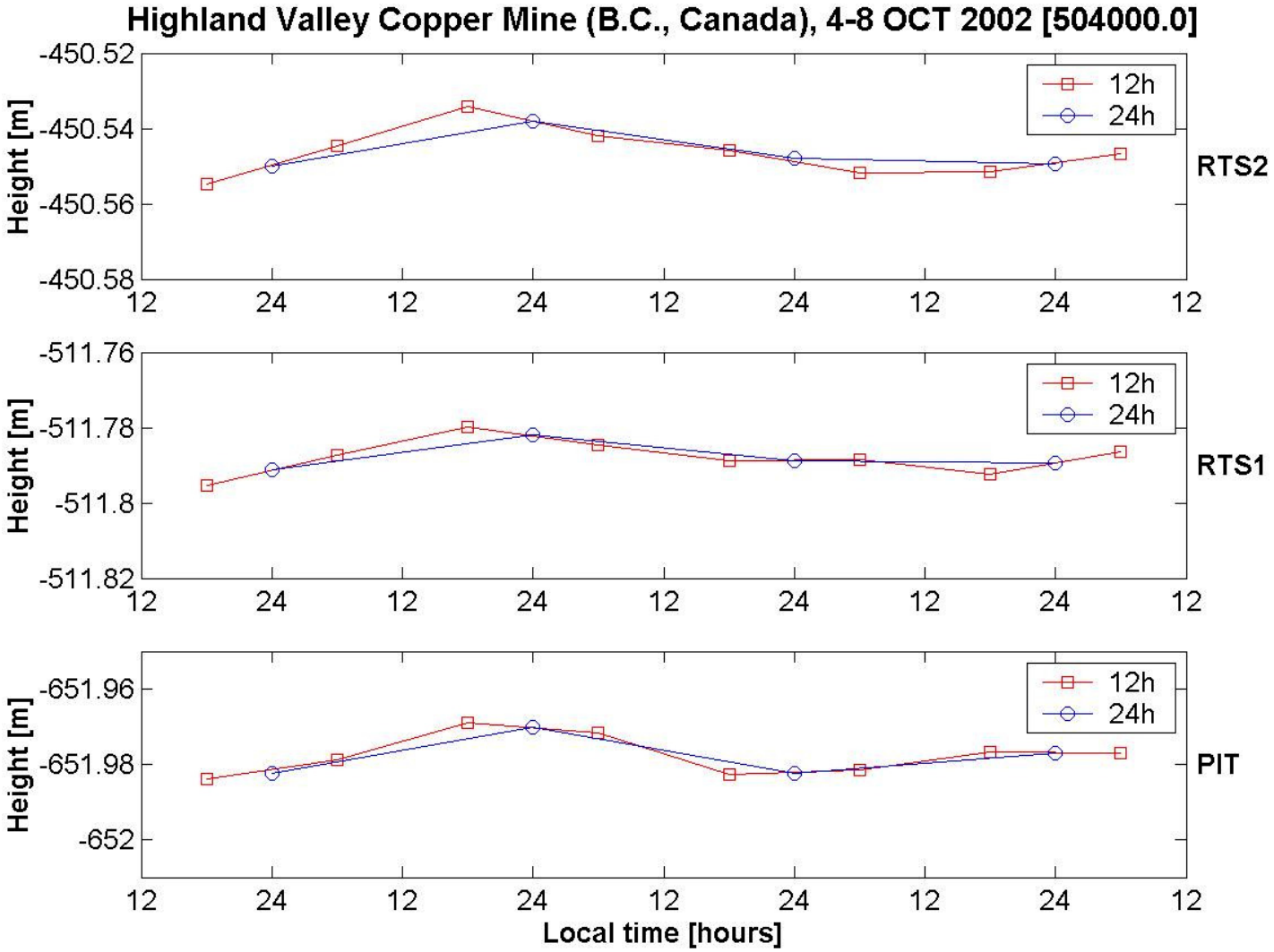
DD MULTIPATH 'OBSERVATIONS"



HEIGHT SOLUTIONS



HEIGHT SOLUTIONS – CONT'D



CONCLUSIONS

- Performance of modified UNB RTK software shows promise
- Still progress to be made to meet requirements
- Two main issues during the first campaign:
  - No absolute reference to validate results (height solutions of the second day?, height solutions of all three stations commonly affected by some errors?)
  - Geometry of satellites limits achievable precision

Further Investigation

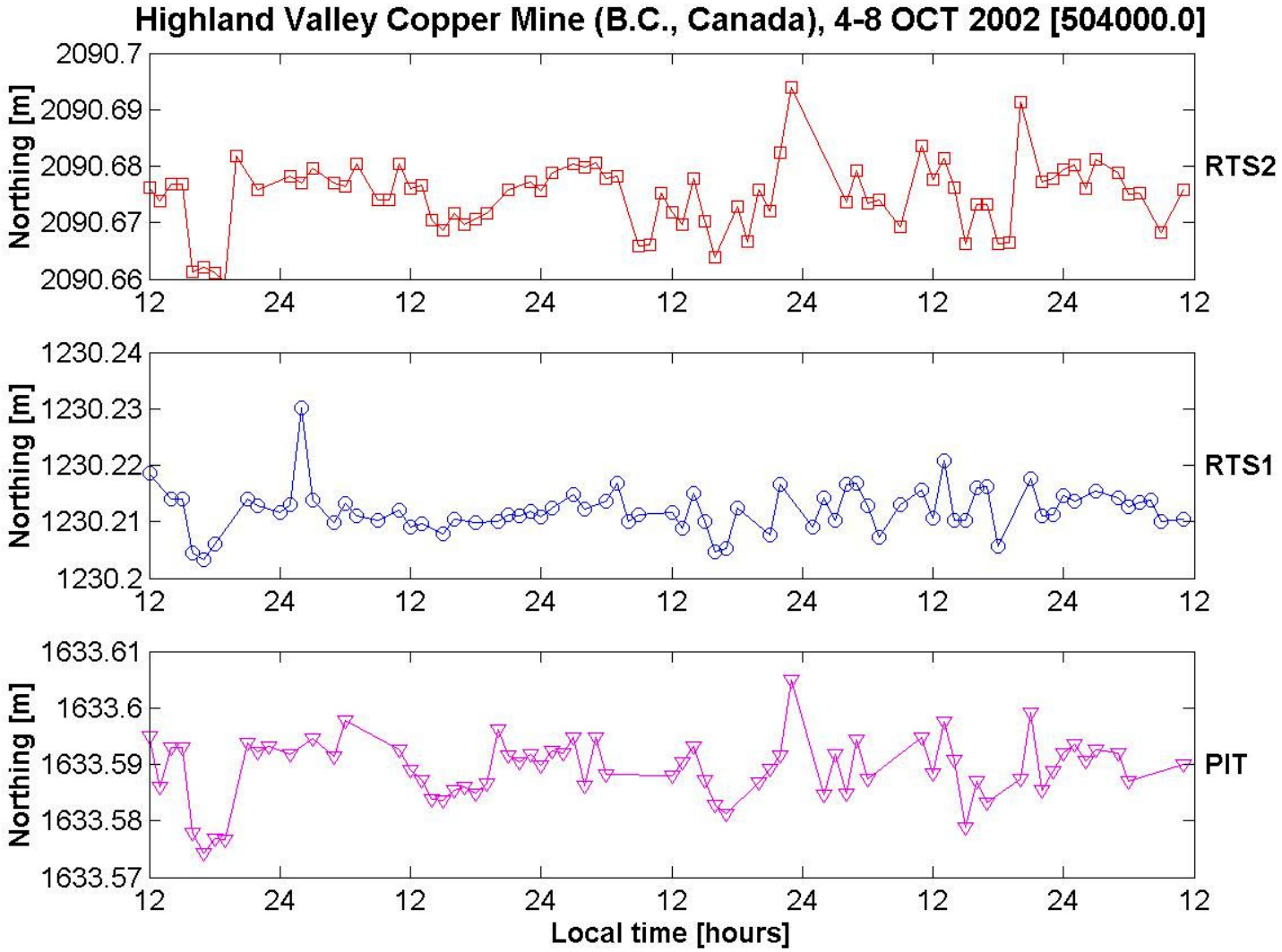
- Use of pseudolites to address the issue of limited satellite availability

- Second campaign:
  - Anomalies (data gaps in observation files, a possible change in position of the MAST station) hinder sound analysis of the current data set
  - Meteorological data to more accurately correlate tropospheric effects with solution variations
  - RTSs used to monitor the stability of the GPS stations

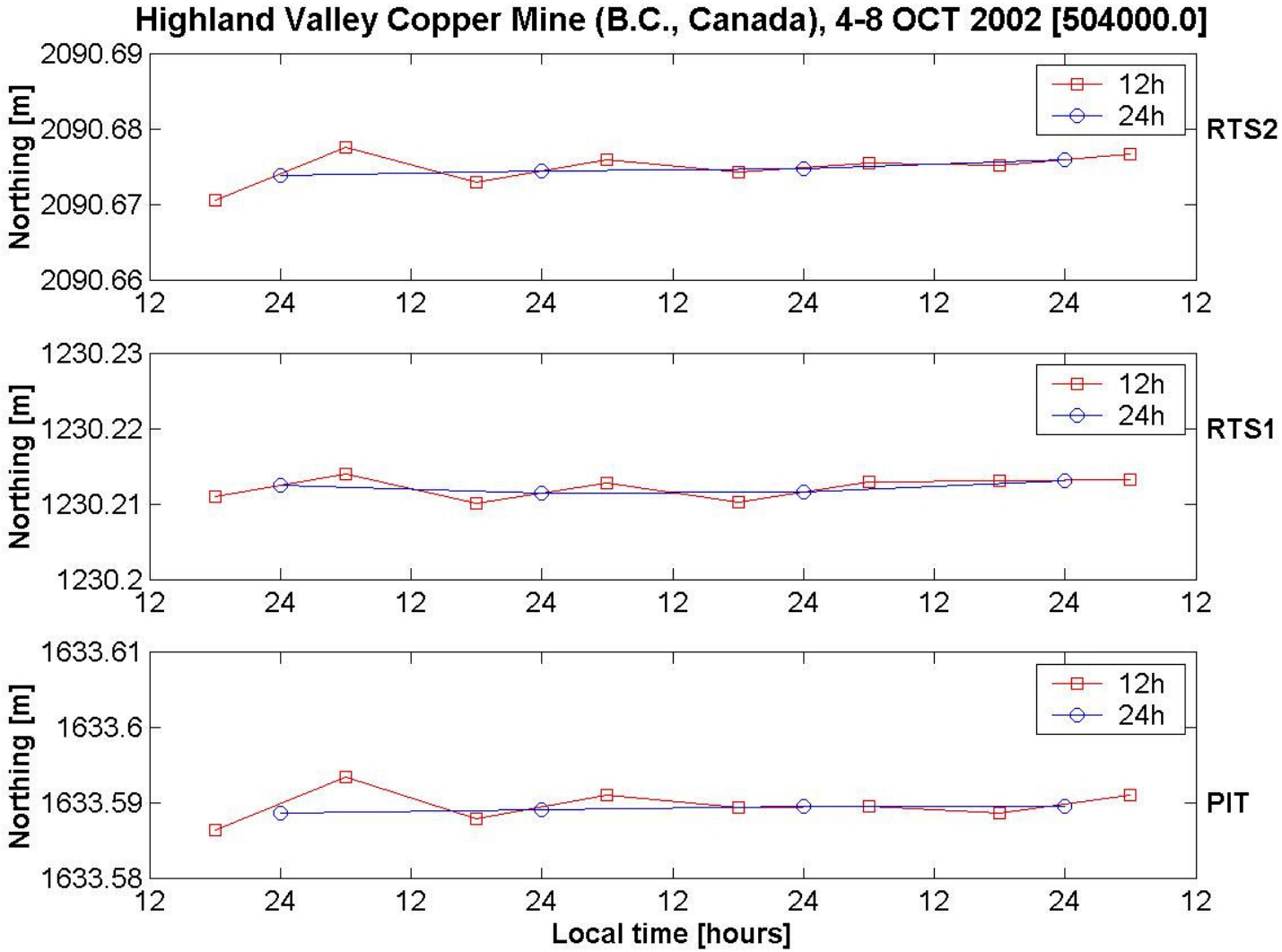
UNB

Ancillary Slides

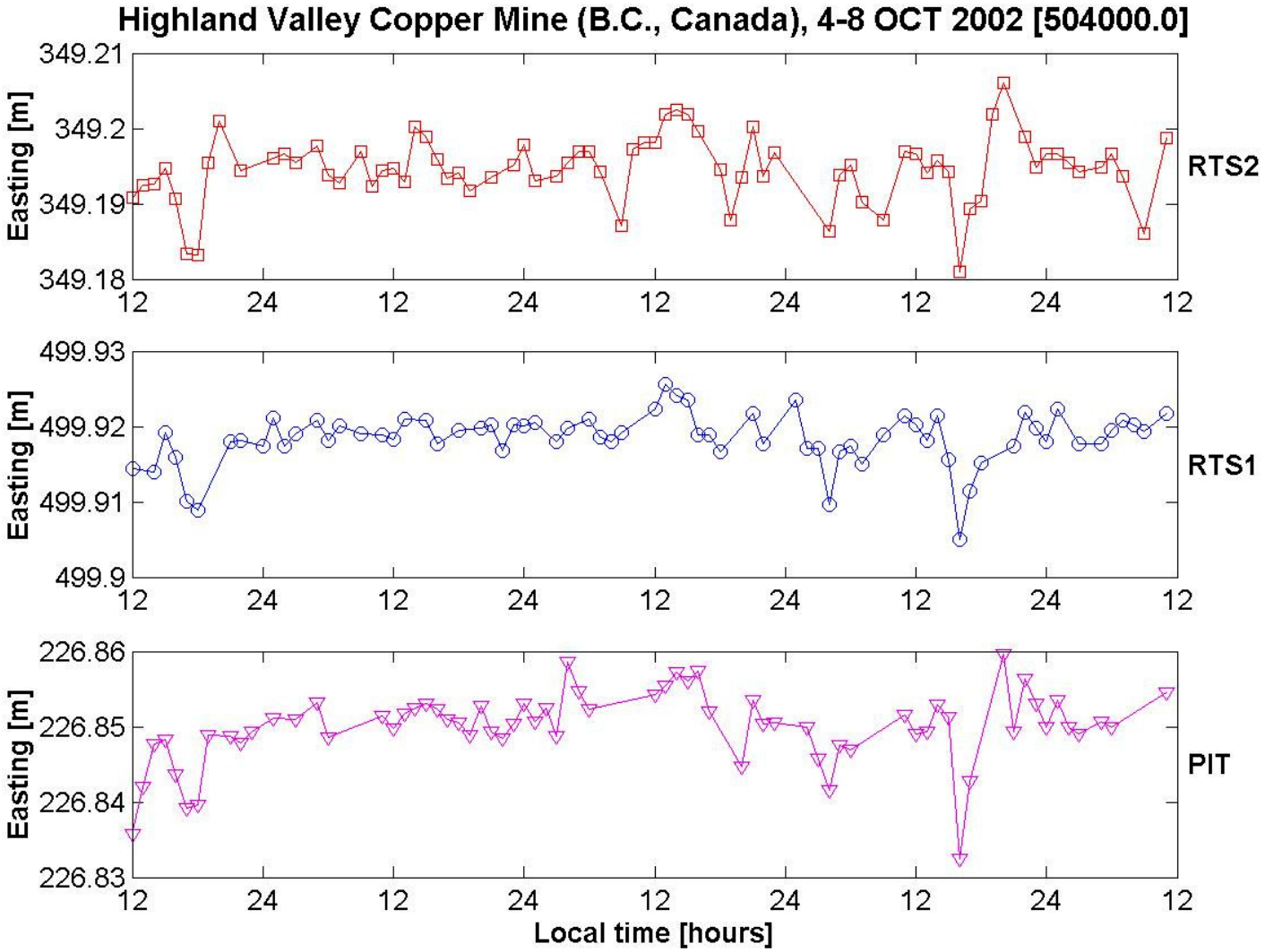
Northing Solutions



Northing Solutions – cont'd



Easting Solutions



Easting Solutions – cont'd